WHAT IS CLAIMED IS:

1. An optical element in which an angle between a [0 0 1] axis of an isometric crystal and an optical axis is less than 10°.

2. An optical element in which an angle between a [0 0 1] axis of an isometric crystal and an optical axis is 0°.

3. An optical element in which an angle between a [0 0 1] axis of an isometric crystal and an optical axis of an optical system using the optical element is less than 10°, and preferably 0°.

4. An optical element in which an angle between a [0 0 1] axis of an isometric crystal and an optical axis of an optical system using the optical element is 0°.

5. A manufacturing method for an optical element comprising the steps of:

growing an isometric crystal; and

forming the optical element from the isometric crystal that has been grown,

wherein the growing step includes the step of controlling growth so that a face orientation of the growing crystal is a <0 0 1> face.

6. A manufacturing method for an optical element comprising the steps of:

growing an isometric crystal; and

forming the optical element from the isometric crystal that has been grown,

wherein the forming step is performed by slicing the isometric crystal parallel to a <0 0 1> face of the crystal.

7. An optical element that is manufactured by a manufacturing method according to claim 5.

8. An optical element according to claim 7, wherein an angle between a [0 0 1] axis of an isometric crystal and an optical axis of the optical element and/or an optical axis of an optical system using the optical element is less than 10°.

9. An optical element according to claim 8, wherein an angle between a [0 0 1] axis of an isometric crystal and an optical axis of the optical element and/or an optical axis of an optical system using the optical element is substantially 0°

10. An optical element according to claim 1, wherein the isometric crystal is fluoride.

11. An optical system according to claim 10, wherein the isometric crystal is any one of calcium fluoride, barium fluoride, and strontium fluoride.

12. A projection optical system including an optical element according to claim 1.

13. A demagnification projection optical system wherein an optical component at an image side includes an optical element according to claim 1.

14. A projection optical system wherein an optical component having a maximum angle between a light beam and an optical axis of 25° or greater includes an optical element according to claim 1.

15. A projection optical system including an optical element according to claim 1, wherein a [0 1 0] axis perpendicular to the [0 0 1] axis is deviated from a characteristic direction of a pattern of a projected object at 10° or greater

16. A projection optical system according to claim 15 wherein the characteristic direction of the pattern forms any angle of 0°, 45°, and 90° with a reference direction of the object.

17. A projection optical system including more than one of the optical elements according to claim 1; the number of which is n, wherein the optical elements are located with one displaced from another around the optical axis so that a [0 1 0] axis perpendicular to the [0 0 1] axis of one of the optical elements and a [0 1 0] axis perpendicular to the [0 0 1] axis of another of the optical elements form an angle within $90/n \pm 10°$ with each other.

18. An optical system including at least one optical element having intrinsic birefringence, wherein the birefringence in the optical system for all pencils of light contributing image forming satisfies the formula:

$b < \lambda/4$

where b denotes wavefront deviation caused by birefringence (unit: nm), and λ denotes a wavelength in use (unit: nm).

19. An optical system according to claim 18, wherein the birefringence n includes birefringence by stress, while the stress birefringence is substantially zero, and the intrinsic birefringence is less than $\lambda/4$.

20. An optical system according to claim 18, wherein the birefringence b further satisfies: $b < \lambda/10$.

21. An optical system according to claim 18, wherein the birefringence b further satisfies: $b < \lambda/20$.

22. An optical system according to claim 18, wherein each optical element consists of an isometric crystal, and a relationship between an axis in a crystal orientation of the optical element and an optical axis is so configured that the intrinsic birefringence of the optical system is $\lambda/4$ or less.

23. An optical system according to claim 22, wherein each optical element consists of an isometric crystal, and a relationship between an axis in a crystal orientation of the optical element and an optical axis is so configured that the intrinsic birefringence of the optical system is substantially $\lambda/10$ or less.

24. An optical system including a plurality of optical elements in which an angle between a [1 1 0] axis of an isometric crystal and an optical axis is less than 10°, wherein one axis of more than one of the optical elements perpendicular to the [1 1 0] axis has a relative angle different from each other.

25. An optical system including a plurality of optical elements in which an angle between a [1 1 0] axis of an isometric crystal and an optical axis is substantially 0°, wherein one axis of more than one of the optical elements perpendicular to the [1 1 0] axis has a relative angle different from each other.

26. An optical system according to claim 24, wherein the more than one of the optical elements is substitutive for an optical component derived from division of the optical elements in a plane perpendicular to the [1 1 0] axis.

27. An optical system according to claim 24, wherein the optical system includes two of the optical elements, and a relative angle of axes of the two optical elements perpendicular to the [1 1 0] axis is 90°.

28. An optical system according to claim 24, wherein the optical system includes two of the optical elements that are equal in thickness to each other, and each of the two optical elements is any one of a parallel flat plate and a lens.

29. An optical system according to claim 24, wherein the isometric crystal is fluoride.

30. An optical system according to claim 29, wherein the isometric crystal is any one of calcium fluoride, barium fluoride, and strontium fluoride.

31. A projection optical system including an optical system according to claim 24.

32. A demagnification projection optical system including an isometric crystal as an optical element, wherein more than one of the optical elements at an image side in which an angle of marginal pencils of light passing through the optical element forms an angle of 24.6° or greater includes an optical element according to claim 26.

33. A projection optical system according to claim 31, wherein an angle between a [1 1 1] axis and an optical axis with respect to a crystal orientation of an isometric crystal is less than 10° in optical elements except the more than one of the optical elements in the projection optical system.

34. A projection optical system according to claim 31, wherein an angle between a [0 0 1] axis and an optical axis with respect to a crystal orientation of an isometric crystal is less than 10° in optical elements except the more than one of the optical elements in the projection optical system.

35. A projection optical system according to claim 31, wherein an angle between any one of a [1 1 1] axis and a [0 0 1] axis of an isometric crystal, and an optical axis is less than 10° in optical elements except the more than one of the optical elements in the projection optical system.

36. A projection optical system according to claim 34 including more than one of the optical elements according to claim 24, forming a first set of optical elements,

wherein a second set of optical elements within the first set of optical elements have the [0 0 1] axis substantially parallel with each other;

wherein the rest of the first set of optical elements, forming a third set of optical elements, have the [0 0 1] axis substantially parallel with each other and perpendicular to the [0 0 1] axis of the second set of optical elements; and

wherein a difference between a total thickness (element thickness on axis) of the second set of optical elements and a total thickness of the third set of optical elements is less than 10mm.

37. A projection optical system according to claim 33, wherein a relative angle of axes perpendicular to the optical axis of the optical elements except the more than one of the optical elements in the projection optical system is changed to reduce intrinsic birefringence.

38. An optical system according to claim 12 that uses a light source of which the wavelength is 200nm or shorter.

39. A projection optical system according to claim 38, wherein the light source is any one of an ArF excimer laser and an F_2 excimer laser.

40. An optical element according to any one of claims 1 through 39, wherein the optical element is one of a lens, a diffraction grating, a parallel flat plate, an optical film, and a combination thereof.

41. An optical system according to any one of claims 1 through 39, wherein the optical element is one of a lens, a diffraction grating, a parallel flat plate, an optical film, and a combination thereof.

42. An exposure apparatus that uses ultraviolet radiation, deep ultraviolet radiation, or vacuum ultraviolet radiation as exposure light, which is projected onto an object to be processed through the optical system according to claim 41 to expose the object to be processed.

43. A device manufacturing method comprising the steps of:

projecting the light for exposure onto the object to be processed using the exposure apparatus according to claim 42; and

performing a predetermined process against the object to be processed to which the light has been projected and exposed.